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IN THE REGION OF THE NEW FOSSIL, DÆMONELIX.

BY FREDERICK C. KENYON.

As important as they have been to the paleontologist in yielding perfect remains of the strange looking mammals of Miocene times, the Bad-lands of Nebraska and South Dakota with the neighboring region have received very little attention outside of some of the early government surveys. From the common geological text books one learns that they are in the bed of a Miocene lake, which like several others of the same times on the other side of the Rocky Mountains, received the bones of the animals living on the surrounding shores and buried them under a great mass of sediment. Nearly all of what little has been written has been taken from the writings of Hayden and the notes of Dr. Evans, neither of whom possessed a camera to enable them to give their readers an adequate pictorial idea of the wonderful region that they describe in a few glowing words.

During the summer of 1893 it was my good fortune to spend several weeks in this region in a party that, in consequence of the generosity of the president of the board of regents of the University of Nebraska, had become known as the "Morrill Geological Expedition." Our main object was to study and collect the strange new fossil made known to science during

the previous spring by Professor E. H. Barbour as *Dæmonelix*, but known for some time to the cowboys and ranchmen of the region where it occurs as "the devil's corkscrew" and "fossil worm."

About noon of the day following our departure from Lincoln we found ourselves in the little town of Harrison, near which Professor Barbour had obtained the one specimen that he had brought back to the University the year before. This is the county seat of Sioux County, which forms the north-western corner of Nebraska. It is not different from the many small towns that one finds on the prairies of the far west. We found a brick court house, a church, a school-house, a hotel, the almost invariable liquor saloon, several stores, and some two dozen or more dwellings. During Harrison's administration the town had received its name and had had its western boom as the chief and only commercial center of some 300 square miles of territory, constituting Sioux County and supporting, according to the last census, less than 2500 inhabitants. During the summer of 1890 Sioux County, in common with a large number of other Nebraska counties, suffered terribly from drouth. Many of the settlers were compelled to abandon their newly made homes to save themselves from ruin. Among those left behind unable to get away, there was intense suffering. During the succeeding winter many private donations of coal and provisions were sent them by the more favored farmers of the eastern counties. In this work of charity even the State was called upon to lend a hand. But this year the few inches of rain that had fallen had put an entirely different aspect upon everything. Many of the deserted homes that might have been seen in the western counties during the spring of 1891 were now reoccupied and everything looked hopeful. About Harrison the landscape was enlivened by innumerable bright colored flowers. Chief among these were many species of *Astragalus* and related genera of leguminous plants. Here and there could be seen the bright colored spikes of the "loco-weed," rendered famous on western prairies by the baneful effect it has upon every horse unlucky enough to eat it. The animals are not killed, but are made so crazy

that they become unmanageable. Throughout the spring and early summer months there is a wonderful profusion of flowers. As fast as one species finishes its blooming period another takes its place; in fact, whatever one sees is but an earnest of what might be, were rain less uncertain, or could the land be irrigated. But for irrigation, since the greater part of the county is so high above the three small streams that drain it, dependence must be placed upon artesian wells, which would cost more than the average ranchman can afford to pay. The consequence is that one seldom meets with a settler anywhere in the county except in the cañons, where water may be obtained with little trouble.

In early times there may have been over a broad strip of country, west of the Missouri River, a dearth of vegetation that made the name of Great American Desert much more appropriate than at present. It is not unlikely, in fact, it is very probable, that Fremont, when he gave origin to the term, was deceived by the aspect produced by the low creeping buffalo grass. In the eastern part of Nebraska the buffalo grass had almost entirely given place to the blue-stem grasses when the state was admitted into the Union. There has been a constant westward movement of vegetation, though it is doubtful whether, outside of man's influence, it has been as rapid as some of the early writers would have us believe. Still, there is an impression constantly met with among the older settlers that there has been a great change in both climate and vegetation. The territory north of the Platte River, known as the "Sand-hills," is said to have been once entirely bare, but it is now covered with grasses. The yearly amount of moisture precipitated is believed to be, on the whole, steadily increasing. In the extreme western part of the state, in early territorial times, one might sleep in the open air without one's blankets being dampened by a single drop of dew. Now heavy dews fall all over the state.

This constant change of climate is commonly accounted for by the western settler by the breaking up of the prairie sod and the cultivation of the soil, which certainly has enabled much of the rain that has fallen to be retained instead of run-

ning off through the creeks to the Missouri River. Occasionally one meets with a very ludicrous explanation; and not the least among the ludicrous is the idea of electrical disturbances produced by iron rails and barbed wire fences. When there were few fences, and the Union Pacific was about the only railroad in the state, the disturbances were said to be produced by the rails, later the barbed wire fences played the chief part in precipitating atmospheric moisture. In reply to such ignorance and credulity, which, by the way, makes it possible for the early lightning rod swindler or his kind to turn rain maker, about all that need be said is that judging from reports from the various prairie states during the present summer, a great many fences must have been taken down.

Near Harrison and southward the surface of the country rises and falls in long, sometimes "rolling hills." From an altitude of 4871 feet at Harrison it rises to considerably over 5000 on the highest point of Pine Ridge northwest of the town and on the western edge of the state. Through this high table land deep cañons have been worn by the White and Niobrara Rivers on the south, while on the north, the deep, broad valley of Hat Creek has been cut out by an insignificant tributary of the south fork of the Cheyenne. Along the northern edge of this table land and along the edges of that forming the divide further eastward between the White and Niobrara Rivers, may be seen numerous clumps of the western or yellow pine which have given the name to the ridge. Back into the ridge have cut numerous deep cañons the branches of Hat Creek. In these, cottonwoods, box elders, ash, elms, willows, and other trees find enough moisture and protection to flourish. In their upper courses they sometimes break up into numerous deep and precipitous ravines, and at the extreme heads of these are found those eroded places that present the appearance of, and are known as "blow outs." In some cases their lack of connection with the ravines leaves no room for doubt that they can be anything else than wind-formed excavations.

It is in these "blow outs" and ravines that the peculiar "cork-screw" fossil is found. In some cases they may be seen

so thickly strewed about as to give the idea of their having formed a veritable forest. Very few other fossils are found with them. The celebrated fossiliferous or Bad-land formation, is far below.

The more perfect of these corkscrew-like fossils consist of an invariably perpendicular spiral, and, running away and upward from its base, a great, log-like stem. The greatest number of whorls that we found in a single specimen was thirteen, which rose to a height of more than eight feet. The stem of this specimen was some thirteen feet long. Sometimes "screws" may be found without a stem, sometimes the spiral, turning either to the right or left, may be broad and open, at others it may be very close. Now and then a specimen may be found in which there is a central pole-like portion around which the spiral turns. More frequently there is found only a few whorls and a short stem.

At a little lower level than that at which we found the finest specimens, very irregular and prostrate forms are common. In the banks of the ravines they look like so many large tree roots exposed by erosion. In one instance a screw with about three whorls was found at this lower level, which, unlike any other that we had seen, ended below in two roots that branched off from one another at a broad angle.

These strange fossils consist of a white substance a little harder than the semi-petrified calcareous sandstone in which they occur, and, when exposed by wind or water, stand out in bold relief against the cliffs or walls of the ravines and "blow outs." In some cases they project like tree stumps, and, strewn about among these, fragments from a few inches to several feet in length are common. The surface of both spiral and stem may vary from fairly smooth to rough and knotty. Often small filaments are broken off in digging, but as sheet-like layers of similar hardness and appearance are frequently broken through, it may be doubtful whether they really belong to the fossil. Sometimes the knots, or even the whole surface, made up of innumerable fine filaments, may look like that of a hard and compact sponge. In the broken cross section an external whitish ring is presented, surrounding a

great core of a color similar to that of the surrounding rock. This is not quite as hard as the external white ring and often shows sections of large white tubular structures.

What this so-called "corkscrew" may be may remain in mystery for some time to come. The sponge-like appearance of some of the specimens seemed to proclaim it a gigantic fresh water sponge. But microscopic examination brought forth no evidence of the spicules that one would expect. All that could be found of an organic nature was in one or two instances a few plant cells. The presence of these, however, might be explained as living cells of rootlets that had worked into the fossil and in no way belonged to it. In one instance a nearly entire skeleton was found in a stem near its junction with its spiral and suggested the idea that our fossil might be nothing more than the core of a rodent hole. Still another supposition was that it is only a concretionary formation. The peculiar and regular form, lack of concretionary structure, and widespread occurrence at once throws aside the last supposition. The regularity of the spiral, the "pole"-like structure in some of the spirals, the fact that the spiral tapers from top to base, and sometimes may have tapering root-like ends, and finally the presence of tubular structures within the spiral and stem, demonstrate the untenability of the "burrow" idea. If the "cork screw" was the underground stem and root of some aquatic plant it becomes very difficult to explain the presence of the skeleton. If it is supposed to be of a sponge-like nature and growing above the lake bed, the presence of the skeleton may readily be accounted for. It might become entangled in the growing sponge mass and surrounded, just as any pebble or shell may be found to be covered by some existing sponges.¹

The uniformity with which the "stem" occurs points to a mode of growth that finds its analogy among some of the

¹ Since this paper was written, I have seen a paper by Prof. Barbour giving the last results of his studies. Sections have been made from all parts of the fossil and from numerous specimens with the uniform result of demonstrating the presence of plant cells. These have an average size of 35 to 50 by 16 microns and an evidently parenchymous nature. Since no others are found, the structure must have been very low in the scale of life.

See University Studies, University of Nebraska, July, 1894.

lower plants and the grasses. This would suppose that a stem starts out from the side, or perhaps the top of a screw and descending downward after awhile sends up a new screw. Then if the connection with the parent screw should be lost through decay, or if the parent screw itself should decay, each "screw" would be left independent. The fact that the distal end of the stem is invariably very rotten lends some weight to this supposition. As yet, no two specimens have been found with any other connection than that produced by crowding.

After three weeks of corkscrew digging in the vicinity of Harrison, we decided to make a short trip southward to the Niobrara, where, we were informed, screws of enormous size, some with tree-like tops, might be found. With the two teams that we had managed to hire in the town, we followed the trail over the prairie to the southeast. Once or twice we passed a lonely "claim," but when these and Harrison had become hidden by the hills behind us, we could look for miles around without seeing a sign of human life. From time to time a jack rabbit would be started and be seen bounding away from our path. The only sounds that we heard, not made by ourselves, were the songs of the black finch (*Calamospiza bicolor*) which was, in fact, very musical. Late in the afternoon we sighted the high hills south of the Niobrara Valley, and towards evening came upon what appeared to be the head of a cañon running down into it. On the lower banks of this a great number of concretions of varying shapes and sizes were strewn about. In general they were oval, and from an inch to several inches through. With the aid of a sledge a number of these were broken off and packed in the wagons. On breaking them they were found to be made up of a great number of thin lamellæ of sandstone, which were alternately dark and light. They lay on the ground as they had been exposed by the erosion of the banks, and were attached to the rock and to one another by small necks.

While busy cracking concretions we were surprised by the ominous aspect of a cloud that had seemed a little while before to be going by, but now was fast coming straight over us. We had barely spread the canvas wagon-covers over the

bows before great drops of rain began to pelt us. In a moment the rain fairly poured down, and we were alternately blinded and deafened by the sharp crackling lightning and the heavy claps of thunder.

If our ribby horses had needed a whip before, they now set off most willingly before the storm. Soon we found ourselves at the edge of the bluff bordering the Niobrara Valley on the north. The valley presented a fine spectacle in the storm. It is not wide, not more than a mile. On the opposite side we could see the steep high bordering hills, and near them the small stream winding through the nearly level valley. By its side the log house of James Cook and his spacious red barns appeared through the misty veil. This was the Agate Springs ranch, whither we had been requested to come to see the giant corkscrews with tree-like tops. Down the declivity before us we went with tightened brakes, which were now and then rendered nearly useless by the slipperiness of the road. We finally reached the level below without mishap, and a little later pulled up before the friendly shelter of the red barns. Shortly after our arrival the rain ceased and we found ourselves in the presence of Mrs. Cook.

Mr. Cook was absent, but during that evening and that of the day following we were most agreeably entertained by Mrs. Cook and Mr. Cook, her brother-in-law. There could have been no greater surprise for us than this finding of so much eastern comfort and refinement so far away from the railroad and civilization. During our entire stay we were most hospitably entertained.

The valley afforded very different scenery from what we had met with farther north. On the south high steep hills rose up from the valley, on the north were high bluffs. Back through these northern bluffs numerous narrow cañons had been cut in times long passed. In none of them was there found a spring or a drop of water. The floor was level and covered with grass. The walls often rose up by a series of great steps which were not infrequently covered with vegetation so that they presented a line of green against the light colored perpendicular walls. On top of some of the bluffs

were outcrops of a thin stratum of siliceous limestone similar to what had been found on some of the hills north of Harrison. Here, however, the siliceous matter was in the form of moss agate and made up by far the larger part of the rock.

In the upper courses of these cañons we found the "corkscrews." We certainly had not been deceived as to their size; the largest that we had seen in the neighborhood of Harrison were pigmies beside some that now presented themselves to view. Few of them were small. Stems and spirals nearly three feet in diameter were not uncommon, but they were not quite so regular and smooth as the smaller ones to which we had become accustomed during our three weeks digging. Many of them were found in which the great spiral seemed to end in a broad top, but in no instance did we see any evidence of the tree-like tops that we had been told were to be found here. The one specimen that was pointed out to us, illustrating this feature, proved to be nothing more than an irregular mass of nodules that had been exposed by the wind and rain in the bank above a "corkscrew." Between the nodules and "corkscrew" there was no connection whatever. These irregular structures of a more or less calcareous nature are very common in the formation in which the corkscrews occur, and may no doubt be found throughout the whole Niobrara formation. They seem to be mentioned by Hayden and others, and it seems strange that the same observers never saw the "corkscrew."

At Agate Springs there were no wash-outs on the south side of the river so as to enable one to say definitely whether the "corkscrew" area extends south of the river. But without doubt they may be found there. During the past year specimens have been found in Dakota, thus extending greatly the large area in which we found them in 1892.

As in the beds near Harrison, fragments were common. One, which came near being left in the field, was turned over and disclosed to view, imbedded in its mass, the legs and several vertebræ of an animal about the size of a large deer. The bones were clamped into the side of the stem just as a

shell might be by a low-growing sponge. This seemed to give additional evidence for the "sponge" idea.

The only other bones that were found on the north side of the river was an *Oreodon* skull. This was dug out a few inches above the upper end of a "screw." On the hills of the other side of the river, however, fragments of *Rhinoceros* were not uncommon.

Nearly all the specimens were so large that we were obliged to content ourselves with a few of such small ones as could be readily dug out. These we carefully packed in hay in the wagons, and after a stay at Agate Springs of only a few days, set about our return for Harrison.

After spending a day in packing up, depositing our precious corkscrews in the store room of the depot where they made a goodly pile of boxes, we left Harrison for the Bad-lands and, eventually, the Black Hills. From the Hills, at the head of Sowbelly Cañon, we caught a glimpse of the great Hat Creek Valley to the northeastward. But the view from here is not nearly as striking as that obtained from the buttes further west and north. One can ride up to the edge of these until the broad expanse of the valley, from seven hundred to a thousand feet below, bursts upon him without warning. These views cannot fail to call forth an exclamation of wonder and admiration. At one's feet it seems as though the valley has been formed by a great fault; eastward and northeast it stretches as far as the eye can reach, on the west it rises into the hills of Wyoming, while on the north it seems bounded by the low-lying dark colored hills, the Black Hills, some seventy miles away. If the atmosphere is favorable, Harney's Peak, the highest point of the dark colored range, may be seen. Through the apparently smooth and floor-like valley meanders Hat Creek, gathering up the waters of its various tributaries as it flows along. Scattered along these tributaries, which run back into the ridge from which the view is taken, may be seen small clumps of cottonwoods, so far away as to appear like brushwood. Nearer by and along the foot of the ridge, fields of grain wave in the breeze, while here and there may be seen herds of cattle, moving specks that recall the

cowboy and the ranchman that but a few years ago held entire control of the region. Scattered about the valley, some near, some far off, appear light colored patches sparkling in the sunlight. In the midst of some of them conical mounds rise up like lonely beacons. These are the Bad-lands of Sioux County, the *Mauvaisés terres* of the French Canadian traders, and the *Ma-koo-tscha* of the Dakotas.

These bare looking spots one finds upon nearer approach to be great "wash-outs" at the head of the numerous branches of the streams flowing into Hat Creek. In some cases they may be five or six square miles in extent or more, and offer some of the finest erosion scenery, perhaps, to be found anywhere. The whole extent of country covered by them is cut up into numerous and intricately branching precipitous ravines. The tops of the divides between the branches are worn down to knife-like edges, but not infrequently a large plot may be entirely cut off from the upland and present the appearance of a small table-land. It is nearly impossible for a traveller to pass through the labyrinth of ravines with a team; even to one on foot they present innumerable difficulties. They illustrate vividly the method by which nature may level the largest of continents.

From the high ridge bordering the valley on the south a descent can be made only through some of the large cañons cutting back into it. One of these is Sowbelly Cañon, which received its euphonious name from the fact that in the time of Indian troubles a body of troops became surrounded while passing through it, and were kept there so long before assistance came that they had nothing to eat but bacon, or, as it is called by the soldiers, sowbelly. Like the other large cañons it has a small stream of clear and good water, and on its sides is covered by trees and underbrush. The walls rise often perpendicularly, their whitish surfaces glistening in the bright sunlight. In some places they are broken through by branching cañons, and the isolated head-lands form buttes of striking beauty. Sometimes they simulate the works of man. One in particular, near the lower course of the cañon, looks like a gigantic castle in ruins. Here and there great breaches

appeared to have been made in the walls, while below were the great mounds of debris. At one corner appears a great ruined tower, while adding to the effect may be seen scattered patches of green where trees and grasses have caught root, and perhaps an inaccessible eyrie on the side of the cliff. When we saw it there were a pair of bald eagles soaring far above. This structure had been not inappropriately named Castle Butte. Before the advent of the white man they were really used as vantage points of defence as is abundantly attested by the large number of arrow heads that one may pick up at the bases of the cliffs.

This butte formation is characteristic of the White River country. It consists of a fine semi-petrified calcareous sandstone, often containing irregular branching and rootlike concretionary formations such as we found abundantly near Harrison and on the Niobrara. In it also are found the "corkscrews." Below it is the bed of the Miocene lake consisting of strata of clays, marls, and sandstone, the erosion of which has formed the Bad-lands rendered famous by the paleontological discoveries of Cope, Marsh, and others.

Leaving Sowbelly Cañon behind we drove several miles down into the valley to escape the worst of the ravines near the ridge, and then turned eastward to hunt over a "patch" of Bad-lands where we were certain of finding *Menodus* remains. About six o'clock, after winding about nearly all day in order to pass the ravines that we could not escape in, in spite of our long detour, we finally reached the railroad near the "patch" of Bad-lands. This we followed to the watering station, Adele. Here we found a depot, a section house, and an artesian well. All through the long hot day's drive after leaving the cañon, we had found no water that did not have considerably more than the chemist's "trace" of alkali. To be sure we carried water, but this could not last long and could not be kept cool. Imagine our disgust when going to the artesian well to quench our thirst to find water so heavily charged with sulphur as to smell perhaps not quite as badly as more or less ancient eggs. We learned that the people at the section house had their water shipped to them from Craw-

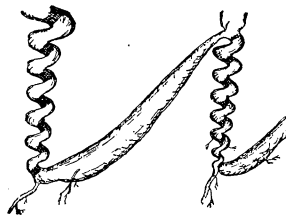
ford, about fourteen miles south of Adele. From them we "borrowed" a little water for present use, and learned of a farm house about a mile away, where we might fill our kegs. Hither we went the next day and every day during our stay in the neighborhood and found water not undrinkable, though slightly alkaline. Our horses were compelled to put up with the sulphur water, but strange to say, they did not seem to object. Perhaps they were better acquainted with the vicissitudes of the Bad-lands than we, and were philosophically willing to appreciate what they could get.

Near the depot we made our camp, sleeping on the ground, which, after pulling up a few of the cacti that were very common, did not make an unendurable bed, after a little experience. In the morning we awoke to gaze at the play of the light on the wall of the Bad-lands to the west of us. They present a beautiful appearance, which cannot be appreciated until one gets into them. Then the apparent wall becomes broken into precipitous ravines and narrow cañons with walls rising at so steep an angle as to make climbing very difficult and often impossible. The bare white surface is worn by innumerable gullies, and the inch or so of cracked, sun-baked, and friable clay rattles down the banks beneath one's feet. Not a sign of vegetation can be seen save from time to time in the cañon beds a single plant, an *Astragalus* perhaps, washed down from above and blooming here in loneliness. On some of the "tables" above, among the grasses, may be found a species of *Oenothera* and several of *Phlox*, closely hugging the ground like mountain plants. Beneath the superficial friable layer the clay forms a soft rock that has become cracked and broken into irregular lumps. Now and then a thin seam of gypsum appears, jutting above the surface, while at some of the lower levels calcedony is very common, often affording fine specimens. At one place appeared an outcrop of sandstone which had been worn into fantastically rounded forms. Almost everywhere may be seen the remains of turtles, some on their backs, some right side up, some projecting from the walls of the ravines, others on the level spots, as heaps of fragments. Few of them are small, and some may be found that will ap-

proach three feet in length. Besides the turtles, *Oreodon* fragments are scattered about. Among the several fine skulls of these animals that we found was one that was entirely perfect and had attached to it some four or five of the cervical vertebrae. On the levels below the three- to four-foot bed of sandstone the scattered remains of that strange looking ungulate, *Menodus* are frequently met with. Careful search will usually reveal an exposed piece that, when carefully followed with pick and chisels, will prove to be an invaluable specimen. During our short stay in the region a perfect lower jaw of *Menodus* was found. It was lying upside down with only one angle exposed. The rest was buried in the lumps of clay, which, from their hardness and tendency to slip upon one another, made digging very difficult. But by dint of much work with chisels, much paste, glue, many strips of cloth and paper, and much more patience, the jaw was finally freed and turned over. It was a fine specimen, all the teeth were present and perfect, and it was not noticeably distorted. In none of the large museums of the east has the author seen a specimen as perfect. The pasted and glued jaw was left in the field that night which, to our anxiety, brought with it a thunder storm. We feared that we should see no more of specimen, or, that it would be totally ruined. Storms severe enough to be cloud-bursts are not unheard of in the region and when they break on the ridge they sweep with terrific force down the gullies and cañons, carrying everything before them to the valley below. Such storms explain the great amount of erosion that has been done, for in none of the cañons, save those that run far back into the ridge and have a growth of trees, can there be found a running stream of water that ever reaches Hat Creek. In some of the larger Bad-land ravines a small stream of water may be found, but such streams are usually swallowed up, leaving a perfectly dry bed before they reach the open plain or have run very far in it. Most of the ravines are completely dry. But the cloud-bursts would carry off the loose, friable, sun-baked earth on the surface of the walls, exposing the indurated clay beneath to be burnt and cracked in its turn.

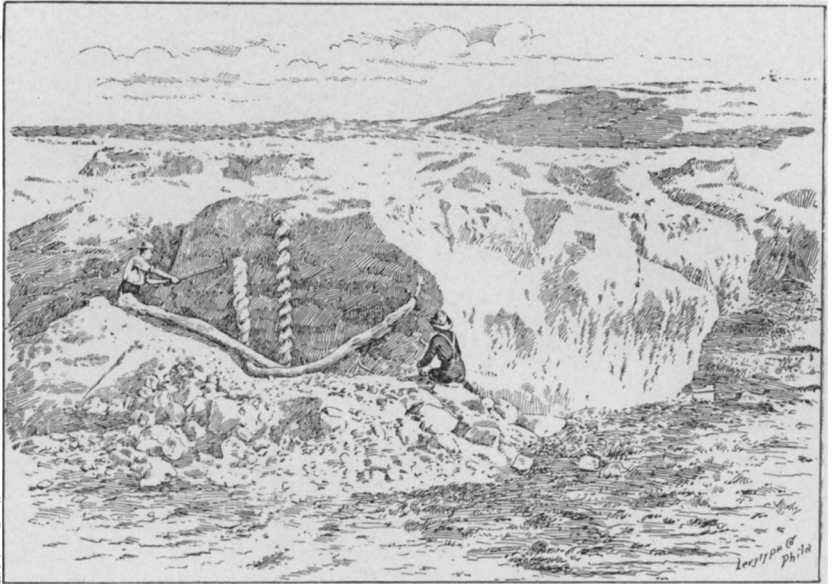
The following morning we hurried to the scene of our labor and found that the storm had not been very severe. There was the jaw, but horrors, the sound teeth of the day before were all cracked and widely gaping, the glue and paste had been washed off and the whole jaw looked as though the lightest touch would knock it into a mass of useless fragments. But not a piece had fallen. Very carefully we went to work, gently pressed the yawning cracks together, and with rags, glue and melted paraffine, made the specimen as good as new.

After packing the jaw and a number of other specimens they were left at the depot to be shipped later on to Lincoln; then we bade adieu to Adele and its bad-smelling water for the more extensive Bad-lands of South Dakota.

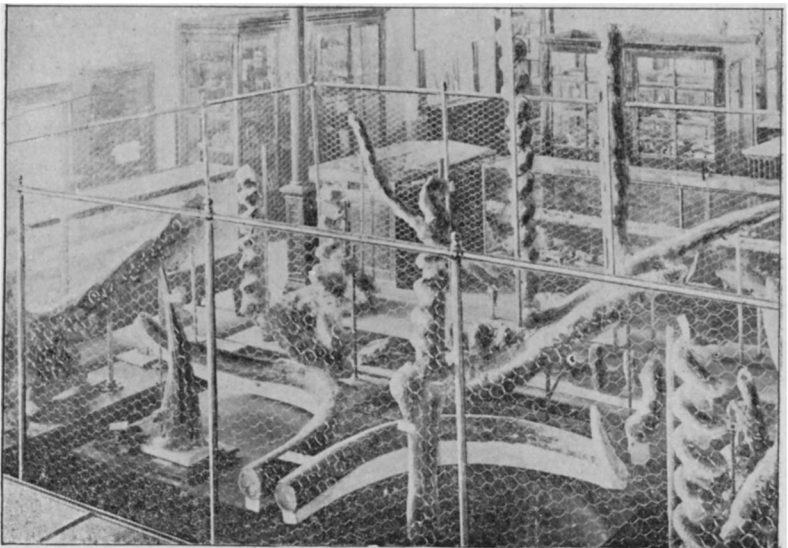


Supposed manner of growth of Dæmonelix.

PLATE XI.



Dæmonelix in place.



Dæmonelix in the Museum at Lincoln, Nebraska.